JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

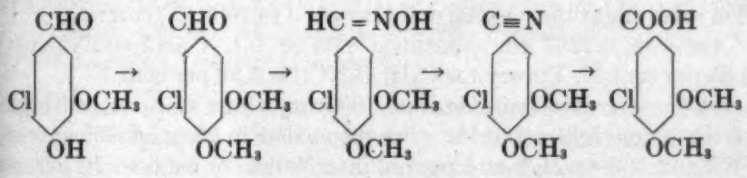
VOL. 24 AUGUST 15, 1934 No. 8

CHEMISTRY.—*The synthesis of 3, 4 dimethoxy-5-chloro benzoic acid.*[1] RAYMOND M. HANN, Private Laboratory of J. P. Wetherill, Washington, D. C. (Communicated by R. E. GIBSON.)

The complete orientation of the possible mono-chloro derivatives of vanillin by Raiford and Lichty[2] has resulted in the confirmation of Hann's[3] assignment of 3-methoxy-4-hydroxy-5-chloro benzaldehyde as the structure for the chloro vanillin obtained by direct chlorination of vanillin in glacial acetic acid.

This structural foundation now allows the utilization of the halogenated vanillins as starting materials in the synthesis of substituted derivatives of veratric aldehyde of known structure. The aldehydes so obtained may be employed in further synthetic operations to yield a series of oriented compounds of the 3, 4 di-methoxy benzene series.

The present communication reports the preparation of 3, 4 dimethoxy-5-chlorobenzoic acid by the classic series of reactions indicated below.



EXPERIMENTAL

5-Chloro-veratric aldehyde (3, 4 dimethoxy-5-chloro benzaldehyde). This substance was prepared by methylation of 5-chloro vanillin by dimethyl sulfate and sodium hydroxide as previously described.[4]

5-Chloro-veratral-anti-aldoxime. Four and four tenths gms. (1

[1] Received April 6, 1934.
[2] RAIFORD and LICHTY. J. Amer. Chem. Soc. 52: 4576. 1930.
[3] HANN, R. M. J. Amer. Chem. Soc. 47: 2000. 1925.
[4] HANN. This JOURNAL, 24: 125. 1934.

mole) of 5-chloro veratric aldehyde, 1.5 gms. of hydroxylamine hydrochloride (1 mole) and 2.8 gms. of sodium bicarbonate (1½ moles) were refluxed for 1 hour with 25 cc. 95 per cent ethyl alcohol, 100 cc. of cold water added and the separated solid filtered, washed with water and dried. Yield 4.5 gms.

Recrystallized from 50 per cent ethyl alcohol it was obtained in long slender acicular colorless needles melting at 90° C. (corr.) to a clear colorless oil.

Analysis: 0.1830 gm. consumed 8.53 cc. 0.1 N acid equivalent to 6.52 per cent N. Theory for $C_9H_{10}O_3NCl$ is 6.50 per cent N.

5-Chloro-veratral-anti-aldoxime acetate. Two gms. of the anti-oxime were dissolved in 5 cc. of acetic anhydride and heated to 35° C. for 10 minutes, the solution treated with an excess of 10 per cent Na_2CO_3 solution, and the oil which first separated brought to crystallization by scratching. The washed precipitate was recrystallized from 65 per cent ethyl alcohol, separating in brilliant colorless needles melting at 84° C. (corr.) to a clear colorless oil. Yield quantitative.

Analysis: 0.2099 gm. consumed 8.01 cc. 0.1 N acid equivalent to 5.34 per cent N. Theory for $C_{11}H_{12}O_4NCl$ is 5.44 per cent N.

5-Chloro-veratral aldoxime hydrochloride. One gm. of the anti-oxime was dissolved in 50 cc. dry ethyl ether and a stream of dry hydrochloric acid gas passed into the solution cooled in ice. The hydrochloride precipitated in small colorless needles which were filtered, washed with ether and dried rapidly in an evacuated desiccator over potassium hydroxide. Immediately after drying the compound melted at 117° C. (corr.) but it rapidly underwent decomposition; over-night the melting point dropped to 100° C. (corr.).

Analysis: 0.2257 gm. consumed 8.95 cc. 0.1 N acid equivalent to 5.55 per cent N. Theory for $C_9H_{11}O_3NCl_2$ is 5.56 per cent N.

5-Chloro-veratral-syn-aldoxime. Twenty three and one tenth gms. of the oxime hydrochloride were suspended in 25 cc. of concentrated HCl and 100 cc. H_2O and poured into 500 cc. of ice cold 10 per cent Na_2CO_3 solution, the precipitate, collected, dried and recrystallized from 50 per cent ethyl alcohol. Yield 18.5 gms. The compound crystallizes in colorless needles melting at 112° C. (corr.) to a clear colorless oil.

Analysis: 0.1201 gm. consumed 5.51 cc. 0.1 N acid equivalent to 6.43 per cent N. Theory for $C_9H_{10}O_3NCl$ is 6.50 per cent N.

5-Chloro-veratronitrile (3, 4-dimethoxy-5-chloro-benzonitrile). Ten gms. of the syn-oxime were dissolved in 10 cc. of acetic anhydride and held at 35° C. for 10 minutes, and the anhydride solution poured into

200 cc. of 10 per cent Na_2CO_3. The separated oil rapidly solidified and was recrystallized from 50 per cent ethyl alcohol. Yield 9.0 gms.

After crystallization from 50 per cent alcohol it was obtained in colorless glistening needles melting at 103° C. (corr.) to a clear colorless oil.

Analysis (Parrbomb): 0.2111 gm. gave 0.1540 gm. AgCl equivalent to 18.05 per cent Cl. Theory for $C_9H_9O_2NCl$ is 17.95 per cent Cl.

5-Chloro-veratric acid (3, 4-dimethoxy-5-chloro benzoic acid).—Five gms. of the crude nitrile was boiled for 1 hour with 50 cc. of 20 per cent NaOH. The nitrile formed an oil which disappeared after 10 minutes boiling and ammonia was detected issuing from the condenser. After cooling the acid was precipitated as a white solid by addition of 100 cc. of 1:4 HCl, filtered, washed with H_2O, and recrystallized from 50 per cent ethyl alcohol. The yield was 4.1 gms.

The acid was obtained as soft silky brilliant needles, melting at 191° C. (corr.) to a clear colorless oil.

Analysis: 0.2234 gm. consumed 10.27 cc. 0.1 N NaOH. Theory for $C_9H_9O_4Cl$ is 10.32 cc.

SUMMARY

5-Chloro-veratric aldehyde has been converted to 3, 4-dimethoxy-5-chloro benzoic acid through acetylation of its syn-aldoxime to form the benzonitrile and subsequent alkaline hydrolysis.

Certain other intermediate derivatives in this series of reactions have been isolated and described.

PALEONTOLOGY.—*A new species of* Pecten *from the Oligocene near Duncan Church, Washington County, Florida.*[1] WENDELL C. MANSFIELD, Geological Survey.

Specimens of orbitoid foraminifera from a limestone near Duncan Church, Washington County, Florida, were described recently by Dr. W. Storrs Cole,[2] and were determined to be of the age of the Glendon formation, a middle Oligocene limestone. Cooke and Mossom[3] had previously referred the limestone near Duncan Church to the Eocene.

At the time that Mr. Gerald M. Ponton of the Florida Geological

[1] Published by permission of the Director of the U. S. Geological Survey. Received May 8, 1934.

[2] COLE, W. STORRS. *Oligocene orbitoids from near Duncan Church, Washington County, Florida.* Jour. Paleont. 8: 21–28, *pls. 3, 4.* 1934.

[3] COOKE, C. W., and MOSSOM, STUART. *Geology of Florida.* Florida Geol. Survey Ann. Rept. 20: 61. 1929.

Survey collected the orbitoids which were studied by Doctor Cole, Mr. Ponton and the writer obtained several fairly good specimens of a species of *Pecten* from the same limestone. The *Pecten* is believed to represent a new species and is described and figured in this paper under the name, *Pecten duncanensis*. In addition to the *Pecten*, fragments of an echinoid, which may be *Clypeaster rogersi* (Morton), an Oligocene species, were collected.

The *Pecten* corroborates Cole's opinion that the limestone is of Glendon age. The limestone appears to be of the same age as fossiliferous silicified chert exposed on Flint River at Bainbridge, Ga., which has been correlated with the Glendon.

The writer also visited a sink on the A. L. Parish Farm, 3½ miles southeast of Wausau, Washington County, Florida, where 20 feet of limestone is exposed. The limestone is separable into two beds, the lower of which is believed to be of the same age as that of the limestone exposed at Duncan Church. The upper bed carries an abundant fauna which, according to Cooke and Mossom,[4] appears to be of Tampa age. However, this fauna has not been studied sufficiently to determine definitely its relationship to the Tampa fauna.

Pecten (Lyropecten) duncanensis Mansfield, n.sp.

Figures 1, 2, 3

Shell small, rather thin, inequilateral, weakly inflated, the left valve more convex than the right. Right anterior ear with a moderately deep notch and sculptured with five rather strong radials, the innermost of which lies close to the submargin, and with transverse closely-spaced imbrications; right posterior ear with six strong, imbricated radials. Disk of right valve sculptured with 23 to 25 (24 on holotype) squarish, scabrous and imbricated ribs, separated by intervals of about the same width as the ribs. The early portion of each rib is narrowly rounded and the later portion nearly square; the latter is undercut on the sides and is ornamented on the top with three scabrous threads, the medial one of which is the strongest. The interradial spaces on the smaller specimens are either without a radial or, if present, it is only faintly indicated. A fragment of a larger shell (fig. 1, U.S.N.M. No. 373056) shows one interradial thread of moderate strength in each space. Ribs and interspaces crossed by imbrications whose edges are about one millimeter apart. Left valve sculptured similarly to the right, except that the interradial thread appears to be more strongly developed. Submargins low and marked with faint radials.

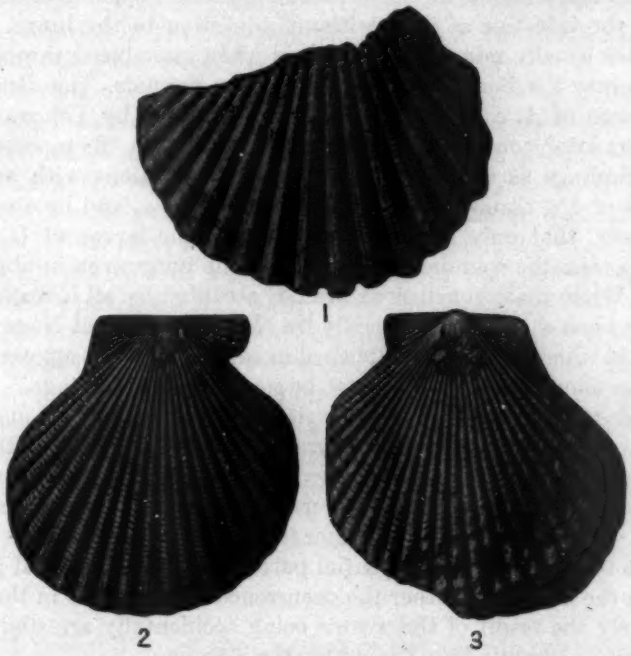
Dimensions of holotype (U.S.N.M. cat. no. 373055): Right valve, length 22.5 mm.; height, 23 mm.; convexity, 4 mm. Paratype (U.S.N.M. cat. no. 373056): Left valve (not entire), length 23+ mm.; height 23+ mm.

Type locality: Station 12724, old quarry near Duncan Church, Washington County, Florida.

Geologic horizon: Oligocene, Glendon formation.

[4] Idem., p. 96.

Pecten duncanensis is closely allied to, if not the same as, specimens figured and incorrectly referred by Dall[5] to *Pecten suwaneënsis* Dall, from the Glendon chert at Bainbridge, Ga. Cooke[6] recognized that the Bainbridge material represented a new species which, however, he did not name. *P. duncanensis* differs from *P. suwaneënsis*, an Eocene Ocala limestone spe-



Figs. 1–3.—*Pecten* (*Lyropecten*) *duncanensis* Mansfield. Figs. 1, 3.—Paratypes ×2. Fig. 2.—Holotype ×2.

cies, in having a higher left valve and squarer ribs which instead of being rounded are ornamented on top with tricarinate radial sculpture. There are four specimens (U.S.N.M. cat. no. 115777) in the U. S. National Museum designated as types of *P. suwaneënsis*. The matrix adhering to these specimens carry foraminifera which have been examined by Mr. Lloyd G. Henbest of the U. S. Geological Survey, who identifies with comparative certainty *Operculina floridensis* Cushman and *O. vaughani* Cushman, both of Ocala, Eocene, age.

The type of *P. suwaneënsis* does not appear to have been figured.

[5] DALL, W. H. Proc. U. S. Nat. Museum, 51: 492, *pl. 83, figs. 2, 3, 4.* 1916.
[6] COOKE, C. W. U. S. Geol. Survey Prof. Paper 133: 5. 1923.

ZOOLOGY.—*The development of the Trichostrongyle,* Nippostrongylus muris, *in rats following ingestion of larvae.*[1] BENJAMIN SCHWARTZ and JOSEPH E. ALICATA, Bureau of Animal Industry.

In the course of investigations on the life history of the dog hookworm, *Ancylostoma caninum,* the view has been advanced by certain investigators that the larvae of this helminth are capable of developing in the intestine of dogs without migration to the lungs. These parasites usually migrate to the lungs when introduced through the mouth into the bodies of small laboratory animals. The direct development of *A. caninum* in dogs was first noted by Yokogawa (7) and was later confirmed by Scott (5). Fuelleborn (2) reported the same findings as a result of experimental infections with another species of dog hookworm, *Uncinaria stenocephala,* and he observed, moreover, that only a small percentage of the larvae of *U. stenocephala* took the roundabout journey to the lungs even in abnormal hosts. While these conclusions are not accepted by all investigators, having been challenged especially by Nakajima (4) and Nagoya (3), the data which have been published in support of what appears to be a rather unorthodox view, seem to be sound and convincing.

During the past few years the writers have been engaged in experimental investigations on the course of infection of rats with *Nippostrongylus muris,* a trichostrongyle nematode of wild rats, readily transmissible to white rats. Several experiments were undertaken with a view to determining whether the migration of the larvae of this species to the lungs is an essential part of the developmental process within the host, or whether the occurrence of the larvae in the lungs is merely the result of the worms being accidentally arrested in the lungs while en route from the skin to the intestine.

Yokogawa (6), who first determined the life history of *N. muris,* noted that white rats could be infected with this worm through the mouth as well as percutaneously; the resultant infestation following the introduction of larvae into the mouth was very slight, and in some cases no infestation could be produced. According to this investigator the infestation resulting from a percutaneous infection was always proportionate to the number of larvae applied to the skin. Africa (1) noted that the intensity of experimental infections of rats by mouth with *N. muris,* as judged by the number of eggs eliminated with the feces of infested animals, was very low as compared to the number of eggs eliminated from percutaneously infected hosts when the rats in both groups were given equal numbers of larvae.

[1] Received May 21, 1934.

While the available evidence indicated that the skin was the more normal portal of entry of *N. muris* into the body of its host, and that the entry of the larvae through the mouth produced but slight infestations or no infestations, no data were available to account for these results. The data obtained by the writers not only have cleared up this point in the life history of *N. muris* but also have a bearing on the question of the biological significance of the migration of the larvae of this species from the intestine to the lungs.

Infective larvae from cultures of rat feces mixed with animal charcoal were introduced into the mouths of 10 rats in a few drops of water with the aid of a small pipette. Rats 1, 5, 9 and 10 received 2,000 larvae each; the remaining rats received 1,000 larvae each. The experimental rats were killed with ether, and were examined post mortem for evidence of worm infestation. The lungs were chopped into small pieces with a pair of fine scissors and put through the Baermann apparatus; this was followed by an examination of each fragment of lung tissue in press preparation. The stomach, small intestine, and large intestine were examined separately with the aid of the Baermann apparatus. Examinations for larvae were also made of the hearts' blood and, in some cases, of scrapings of the intestinal mucosa, as well as of the liver and intestinal lymph glands; the latter two tissues were examined in press preparation and with the Baermann apparatus. In a number of instances the feces of the experimental rats were examined for larvae.

PROTOCOLS

Rat 1 (killed 3 hours after feeding of larvae)—15 infective larvae in small intestine, one of which was obtained by scraping the mucosa; 95 infective larvae in large intestine; some of the larvae from both locations sluggish, giving but a feeble response to tactile stimulation with the dissecting needle; other larvae normally active.

Rat 2 (killed 3 hours after feeding of larvae)—9 infective larvae in stomach; 25 infective larvae in small intestine; 32 infective larvae in large intestine. All larvae alive.

Rat 3 (killed 5 hours after feeding of larvae)—10 live larvae in large intestine.

Rat 4 (killed 18 hours after feeding of larvae)—2 dead larvae in large intestine and 23 dead larvae in feces.

Rat 5 (killed 24 hours after feeding of larvae)—9 live third-stage larvae in lungs.

Rat 6 (killed 30 hours after feeding of larvae)—9 live third-stage larvae in lungs; 1 dead larva in large intestine.

Rat 7 (killed 35 hours after feeding of larvae)—10 live third-stage larvae in lungs; 2 dead larvae in large intestine.

Rat 8 (killed 42 hours after feeding of larvae)—5 live third-stage larvae in lungs.

Rat 9 (killed 48 hours after feeding of larvae)—5 live fourth-stage larvae in small intestine.

Rat 10 (killed 72 hours after feeding of larvae)—2 live larvae in lungs; 44 live fourth-stage larvae in small intestine.

DISCUSSION

It is evident from these data that following the ingestion of infective larvae of *N. muris* by white rats, the worms passed into the stomach, where they were found 3 hours after ingestion. From the stomach the larvae passed into the small intestine in which location some of them became sluggish. Many larvae passed down into the large intestine where they were found still alive 5 hours after ingestion. The larvae died in the large intestine without undergoing any development and passed out with the feces (rat 4). A small number of larvae apparently bored into the wall of the small intestine, as evidenced by the discovery of 1 larva in the scrapings of the intestinal epithelium of rat 1, and subsequently got to the lungs.

In the series of experiments described in this paper, larvae were not found in the lungs from 3 to 18 hours following their ingestion; larvae were recovered from the lungs of experimentally infected rats from 24 to 72 hours after experimental feeding. While larvae, showing no development beyond that of the infective stage, were found in rats 3 hours after feeding, they were absent from the small intestine between 5 and 42 hours after feeding, reappearing again as fourth-stage larvae from 48 to 72 hours after feeding. These observations are in agreement with those of Yokogawa (6) who noted that following percutaneous infection, *Nippostrongylus* larvae appeared in the lungs in from 14 to 20 hours, remained in this location until 50 to 65 hours, and occasionally as late as 72 hours, after having been placed on the skin.

The development and migration of *N. muris* in white rats, following ingestion of infective larvae, followed the same course as observed by Yokogawa (6) subsequent to percutaneous infection. The larvae migrated to the lungs, where they continued their development to the

fourth stage[2] and finally returned to the small intestine. The larvae which failed to penetrate the intestinal mucosa following ingestion, and apparently the vast majority of larvae introduced into the mouth did fail, passed into the large intestine where they died and were subsequently eliminated from the body. No evidence was found of the development of larvae in the intestine without migration to the lungs. Apparently the series of developmental changes in *N. muris* which takes place in the lungs of the host and which culminates in an ecdysis, did not occur as long as the worms remained in the intestine. The migration of the larvae to the lungs appears to be an essential step in the developmental history of these parasites, the worms not being adapted to survival in the small intestine until the completion of the second ecdysis in the lungs; the first ecdysis takes place outside of the host, the larva attaining the infective stage following the first molt, and the final ecdysis takes place in the intestine.

SUMMARY

When introduced into the mouths of white rats, *Nippostrongylus muris* passed into the stomach, some larvae surviving in the stomach for 3 hours, and thence into the small intestine. A relatively small percentage of larvae evidently penetrated the intestinal mucosa and reached the lungs. Other larvae passed into the large intestine where they died and were expelled with the feces.

The larvae which migrated from the intestine to the lungs developed in the normal way; larvae were found in the lungs of white rats from 24 to 72 hours after experimental feeding.

Live larvae showing no development beyond that of the infective stage were found in the intestine of white rats up to 5 hours after experimental feeding; no larvae were found in the small intestine from 18 to 42 hours after experimental feeding, though in three out of four rats involved larvae were present in the lungs during these periods. Two rats killed 48 and 72 hours, respectively, after experimental feeding, contained fourth-stage larvae in the intestine.

The data presented in this paper indicate that the larvae did not develop in the small intestine to the fourth stage, but that the time of the appearance of fourth-stage larvae in the small intestine, coupled with the finding of larvae in the lungs, warrants the conclusion that

[2] According to Yokogawa (6) *N. muris* molts only three times, namely, once as a free-living larva, once in the lungs and once in the intestine. The writers have followed Yokogawa in regarding the development of the larvae in the lungs as involving two stages, one molt being suppressed.

the third-stage larvae developed in the lungs and returned to the intestine as fourth-stage larvae.

The migration of *N. muris* to the lungs appears to be an essential part of their life history, irrespective of their path of entry into the body of the host.

It may be concluded that *N. muris* passes through three distinct developmental phases in the course of its life cycle, namely: (1) The free-living stage, involving one ecdysis, following which the worms emerge as second-stage infective larvae; (2) the pulmonary parasitic stage, in the course of which the larvae develop to the third stage and finally to the fourth stage, the latter stage preceded by an ecdysis; (3) the intestinal parasitic stage in the course of which the larvae grow to the fifth or final stage, preceded by a third ecdysis, followed subsequently by the development of the worms to fertile maturity.

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This paper was read at a meeting of the Third Pan-Pacific Science Congress held in Tokyo in 1926. The date of publication is uncertain.

ZOOLOGY.—Sphaeropomatus miamiensis, *a new genus and species of Serpulid polychaete.*[1] AARON L. TREADWELL. (Communicated by MARY J. RATHBUN.)

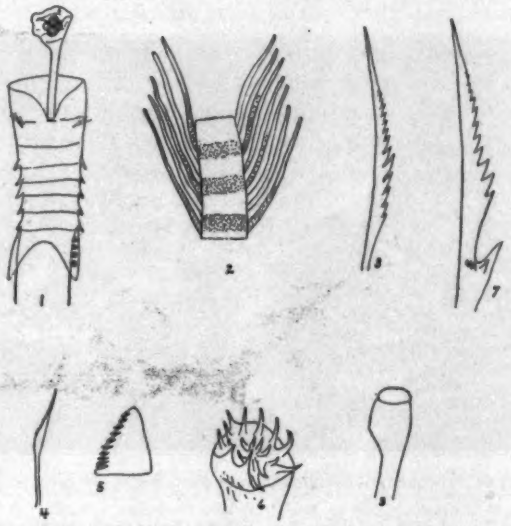
In May 1933, Captain John W. Mills presented to the United States National Museum an unusually large and perfect specimen of the fresh-water shrimp *Macrobrachium jamaicense* from the Miami River,

[1] Published by permission of the Secretary of the Smithsonian Institution. Received March 12, 1934.

Florida, upon the carapace of which were a number of Serpulid worm tubes. These tubes upon examination were found to belong to a new genus and species of annelid which I now name *Sphaeropomatus miamiensis*.

Sphaeropomatus, n. gen.

Peculiar toothed setae borne on the first thoracic somite. Collar prominent, thoracic membrane small. Operculum spherical, supported on a smooth



Figs. 1–5.—*Sphaeropomatus miamiensis*. Fig. 1.—Anterior end of body showing operculum with blood spheres, ×20. A few eggs lie under the thoracic membrane. Fig. 2.—Detail of rachis with filaments, ×68. Fig. 3.—Toothed seta from first somite, ×250. Fig. 4.—Geniculate abdominal seta, ×250. Fig. 5.—Thoracic uncinus, ×600. Fig. 6.—Operculum of *Mercierella enigmatica* after Munro, ×23. Figs. 7, 8.—*Ficopomatus* sp. after Southern. Figs. 7.—Toothed seta from first somite. Fig. 8.—Operculum.

heavy stalk. No spines or other processes on the operculum. Tube calcareous, smooth, cylindrical.

Sphaeropomatus miamiensis, n. sp.

The body of the type is 8 mm. long (including the branchiae), and is never more than 0.5 mm. broad. Branchiae not more than 7 on a side, with heavy rachids (fig. 2), and long, slender filaments, the end of each rachis being bare. From 6 to 9 dark brown bands cross the rachis continuing on to the filaments. The lesser number occurs where the bands have coalesced and are accordingly broader. Similar pigment shows on the uncinal region of the thorax, but elsewhere the body is uncolored. The opercular stalk is formed of the dorsalmost rachis of one side. I cannot say if it is always on

the same side. In normal conditions the operculum is evidently spherical, but in most of my material it is more or less wrinkled. It sometimes contains rounded bodies (fig. 1), commonly regarded as eggs, but they more probably are, as maintained by McIntosh (1926), masses of coagulated blood. The collar (fig. 1), is one-lobed, the halves separated on the dorsal surface. The thoracic membrane is obscure, most clearly visible at its posterior end. The eggs, in the specimen drawn, were lying between the thoracic membrane and the body wall.

There are 6 thoracic somites. On the first is a tuft of rather long setae which are toothed on the terminal portions. At the base of the tuft are a

Fig. 9.—Part of carapace of *Macrobrachium jamaicense* showing worm tubes, ×2.

few very small and slender simple setae without any teeth. Other thoracic setae are smooth, sharp-pointed and not limbate. Uncini begin on the second thoracic somite and continue throughout the body in a single row in each torus. The toothed setae of the first somite are of especial interest. Each (fig. 3) is widened toward the end and then curves to end in a sharp point. At the widening is a double row of teeth, only one row being visible in profile. The basal teeth are very small, the following ones are larger as far as the fifth which is the heaviest of all. Beyond this there is a progressive diminution in size. The other thoracic setae are as described above. The thoracic uncini are extremely small, but under a magnification of 1200 diameters it is possible to see that each carries 10 minute sharp teeth and a basal knob (fig. 5). Abdominal uncini are similar to these but are more narrowly triangular in form. Abdominal setae are geniculate and small, carrying minute denticulations along the margin of the blade (fig. 4). Especially in the posterior abdominal somites these have very long shafts which extend to a considerable distance from the body wall.

The pygidium is bilobed, each lobe short and thick.

The tubes containing the animals were found attached to the carapace of a shrimp *Macrobrachium*. They are very small at the beginning but enlarge rapidly. In cross section they are circular and the surface is smooth (fig. 9).

Three genera of serpulids having toothed setae in the first somite have been described, all found in water supposedly fresh, but probably more or less brackish. *Mercierella* Fauvel (1922, pp. 424–430) was originally found in a canal at Caen, France, and *Ficopomatus* Southern (1921, p. 655) was collected in Chilka Lake, India. *Sphaeropomatus* differs from *Mercierella* in not having a prominent reflexed collar and in having an operculum devoid of spines. As figured by Munro (1924, p. 655), *Mercierella* has prominent spines on the surface of the operculum (fig. 6). The toothed setae are similar in the two genera as are the uncini, but from figures given by Fauvel and Munro I infer that the latter are much smaller in *Sphaeropomatus*. The tube of *Mercierella* has at intervals circular shelf-like rings which do not appear in *Sphaeropomatus*. For *Ficopomatus* Southern does not give the character of the collar, but the operculum (fig. 8) and the toothed setae are very different. A comparison of the two setae is given in figs. 3 and 7. The tube of *Ficopomatus* is described as flattened along the line of attachment and as having a longitudinal ridge along its outer border.

The type is No. 20074 in the collections of the United States National Museum.

The specimens were sent me by Dr. W. L. Schmitt of the U. S. National Museum, who found them when studying the shrimp *Macrobrachium* from the Miami River, Florida. I am also indebted to Dr. Schmitt for portions of the carapace of the shrimp on which were a number of tubes. Acknowledgment is made to Mr. C. R. Shoemaker for sending the precise diagnosis of *Ficopomatus*.

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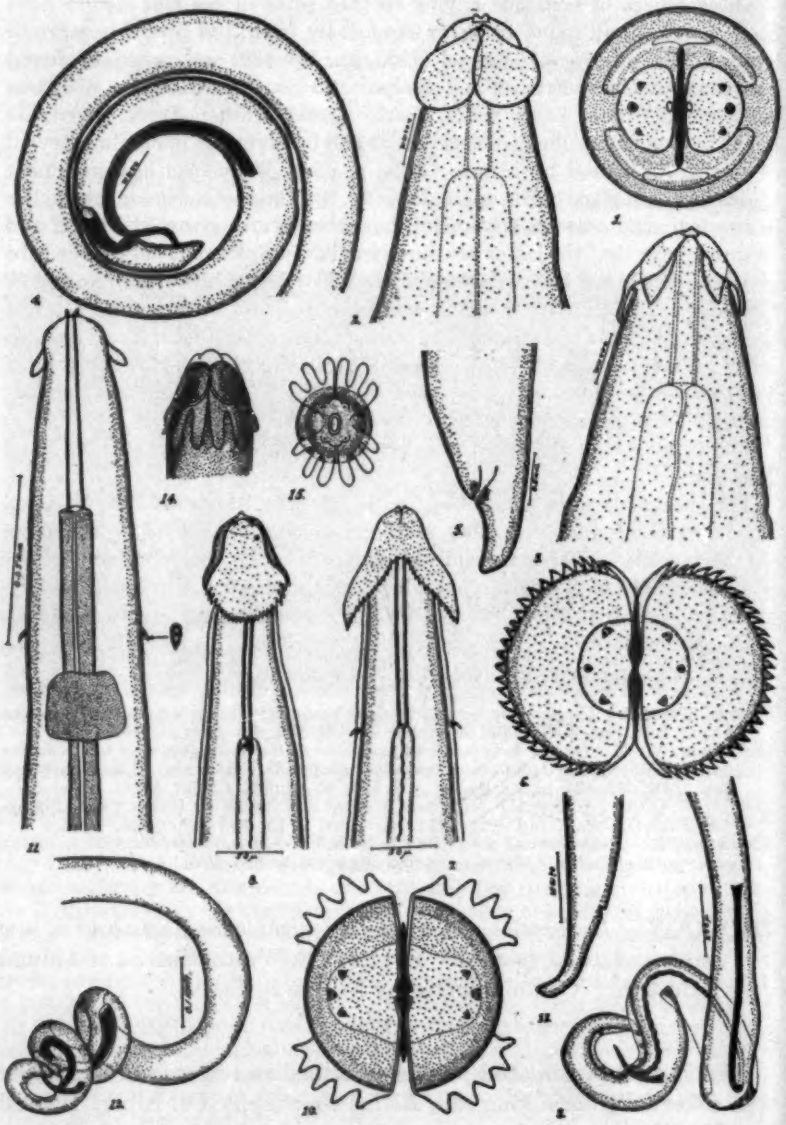
ZOOLOGY.—*Descriptions of three bird nematodes, including a new genus and a new species.*[1]

EVERETT E. WEHR, Bureau of Animal Industry. (Communicated by ELOISE B. CRAM.)

I

The first lot of nematodes to be described and figured in this paper was collected from a king rail, *Rallus elegans*, by Dr. Albert Hassall in 1893. The preserved specimens, consisting of two males and three females and representing a new species, *Schistorophus cucullatus*, were

[1] Received March 12, 1934.



Figs. 1–15.—For explanation see opposite page.

in excellent condition for study. This paper includes, apparently, the first record of a species of the genus *Schistorophus* to be recorded from this continent. The members of this genus represent a very interesting and little studied group of nematodes.

Schistorophus cucullatus new species

Diagnosis.—Schistorophus: Oral opening dorso-ventrally elongated, surrounded by 2 pseudolabia from which project anteriorly 2 cuticular processes, 1 on each lateral side of mouth opening (Fig. 1); interlabia absent. A pair of submedian papillae and an amphid on each pseudolabium. Two dorsal and 2 ventral flap-like cuticular structures arranged in form of hood surrounding anterior extremity of body just posterior to pseudolabia (Figs. 2 and 3), 1 flap of each pair slightly overlapping the other in dorsal and ventral views (Fig. 2). Buccal cavity cylindrical and well developed, its wall heavily chitinized. Esophagus divided into an anterior muscular and a posterior glandular portion.

Male 10 to 11 mm. long and 77μ in maximum width. Buccal cavity about 100μ long. Anterior portion of esophagus about 810μ, posterior portion 1.42 mm., long. Nerve ring 220μ from anterior end of body. Posterior extremity spirally coiled in ventral direction, tip abruptly pointed. Caudal alae narrow, about 1 mm. long. Six pairs of preanal and 4 pairs of postanal papillae (Fig. 4). Spicules unequal and dissimilar, the longer 1.1 mm. long and terminating in a bluntly rounded tip, the shorter about 300μ long, broad and twisted at distal end.

Female 28 mm. long and 315μ in maximum width. Buccal cavity about 115μ long. Anterior portion of esophagus presenting a laterally displaced loop near middle of length due, perhaps, to fixation, and measuring in a straight line about 810μ long; posterior portion 1.88 mm. long and only slightly wider than anterior portion. Nerve ring about 220μ from anterior end of body. Posterior extremity abruptly narrowed at level of anus, tip abruptly pointed (Fig. 5). Vulva 14.3 mm. from anterior end of body, not prominent. Vagina directed posteriorly. Tail about 300μ long. Eggs 48μ by 32μ, with very thick shells, not embryonated *in utero*.

Host.—Rallus elegans.

Location.—Underneath tunic lining of gizzard.

Locality.—North America (United States [Virginia]).

Type specimens (male and female).—U.S.N.M. Helminthological Collection, No. 6268-A.

Paratypes.—U.S.N.M. Helminthological Collection No. 6268-B.

Figs. 1–5.—*Schistorophus cucullatus.* Fig. 1.—Head, en face view. Fig. 2.—Anterior extremity, dorsal view. Fig. 3.—Anterior extremity, lateral view. Fig. 4.—Posterior extremity of male, lateral view. Fig. 5.—Posterior extremity of female, lateral view. Figs. 6–9.—*Steyophorus stellae-polaris.* Fig. 6.—Head, en face view. Fig. 7.—Anterior extremity, dorsal view. Fig. 8.—Anterior extremity, lateral view. Fig. 9.—Posterior extremity of male, lateral view. Figs. 10–15.—*Yseria coronata.* Fig. 10.—Head, en face view. Fig. 11.—Anterior extremity, dorsal view. Fig. 12.—Posterior extremity of male, lateral view. Fig. 13.—Posterior extremity of female, lateral view. Fig. 14.—Head, en face view. After Drasche, 1884. Fig. 15.—Head, lateral view. After Drasche, 1884.

Molin (1) described a species of nematode, *Histiocephalus laciniatus*, from the gizzard of the rail, *Rallus cayennensis;* this species was later transferred to the genus *Schistorophus* by Railliet (2) in 1916. However, inasmuch as *Schistorophus laciniatus* is described as 7 mm. and 14 mm. long, in case of male and female respectively, with head encircled by a fringe of long slender processes and with male tail bearing 24 papillae, the American material here described is considered distinct from that species. The possibility is recognized, however, that *S. cucullatus* may prove to be a synonym of *S. laciniatus* should the type material of the latter species be more completely described. *Schistorophus cucullatus* may be differentiated from the other better described species of this genus by its having fewer papillae on tail of male, by its much larger size, and its differently shaped head structures.

II

The second lot of nematodes was collected by the Bureau of Biological Survey from the fulmar, *Fulmarus glacialis glacialis*, and the Brunnich's murre, *Uria lomvia lomvia*, in the arctic region, the locality designation being that given below. The writer has identified this material as a species described by Parona (3) as *Histiocephalus stellae-polaris*.

The systematic position of *H. stellae-polaris* has been uncertain because of its too meagre description. The species was placed in *Streptocara* by Skrjabin (4) and in *Yseria* by Gedoelst; (5) however, according to the more complete description of this species herein given, it cannot be allocated to any of these genera, for the reasons discussed below. As a result a new genus, *Stegophorus*, has been created for it.

Stegophorus new genus

Diagnosis.—Acuariidae: Oral opening dorso-ventrally elongated, surrounded by 2 pseudolabia, each bearing a pair of submedian papillae and a small amphid (Fig. 6). A helmet-like cuticular structure surrounding head, not extending farther anterior than base of pseudolabia; posterior margins denticulated. Buccal cavity cylindrical, elongated; its wall cross-striated. Esophagus consisting of an anterior short, narrow, muscular portion and a posterior long, broad, glandular portion. *Male*: Caudal alae well developed, terminating slightly anterior to tip of tail. Four pairs of preanal and 5 pairs of postanal pedunculated papillae. Spicules very unequal and dissimilar, the longer one assuming a braided or closely twisted condition in posterior half. Gubernaculum absent. *Female:* Vulva postequatorial. Uteri divergent. Eggs embryonated *in utero*.

Type species.—*Stegophorus stellae-polaris* (Parona, 1901) n. comb.

Stegophorus stellae-polaris (Parona, 1901) n. comb.

Synonyms.—*Histiocephalus stellae-polaris* Parona, 1901; *Streptocara stellae-polaris* (Parona, 1901) Skrjabin, 1916; *Yseria stellae-polaris* (Parona, 1901) Gedoelst, 1919.

Diagnosis.—Stegophorus: Helmet-like cuticular structure (Figs. 7 and 8) surrounding anterior end of body, 87.6μ long, and denticulated on free margins; this structure not in form of a collarette around base of pseudolabia as in *Yseria*, *Streptocara*, and *Seuratia*. Extremities of body attenuated, the anterior more gradual than posterior. Cervical papillae tricuspid, situated at level of junction of buccal cavity with anterior portion of esophagus. Nerve ring near equator of anterior portion of esophagus.

Male 5 to 6 mm. long and 102μ in maximum width. Buccal cavity about 190μ long. Anterior portion of esophagus 400μ long and 15 to 20μ wide; posterior part 1.28 mm. long and about 30 to 40μ wide. Cervical papillae (Fig. 8) about 180μ from anterior end of body. Spicules (Fig. 9) very unequal and dissimilar, the longer 1.6 to 2.43 mm. long, slender, enlarged proximally and pointed distally, with the posterior half, except tip, appearing as a twisted rope, the twisting grading into a braided condition in the distal third; shorter spicule 65 to 100μ long, slightly curved and gradually narrowing towards tip. Caudal alae relatively broad and long, supported by 4 pairs of preanal and 5 pairs of postanal papillae, the latter arranged as follows: 3 pairs just posterior to anal opening, 1 pair near tip of tail, and 1 pair slightly more than one-half the distance from anal opening to tip of tail.

Female 12 to 16 mm. long and 148μ in maximum width. In specimen 13 mm. long, buccal cavity 200μ long, anterior portion of esophagus 511μ long and about 20 to 25μ wide, posterior portion 1.38 mm. long and about 35 to 45μ wide, cervical papillae 204μ and vulva 7.05 mm. from anterior end of body; position of latter indicated by a slight cone-shaped prominence. Vagina directed posteriorly. Amphildelphic. Posterior extremity obtusely rounded, curved slightly ventrad. Anal opening about 200μ from tip of tail. Eggs 44μ by 24μ, embryonated *in utero*.

Hosts.—Fulmarus glacialis glacialis, Thalassodroma pelagica, Uria lomvia lomvia.

Location. Not stated; probably underneath tunic lining of gizzard.

Locality.—Arctic region and British Isles. No specific locality in arctic region was designated by Parona; the recent collections were made at Lat. 73.20 N., Long. 17.25 W. and Lat. 72.00 N., Long. 13.30 W., for *Uria lomvia lomvia*. Lat. 61.00 N., Long. 32.10 W., for *Fulmarus glacialis glacialis*, according to the Bureau of Biological Survey. Baylis (6) reported *Streptocara? stellae-polaris* from the fulmar petrel (*Fulmarus glacialis*) in the North Sea, and the storm-petrel (*Thalassodroma pelagica*) in Norfolk, England

The above redescription is based on specimens in the U.S.N.M., Bureau of Animal Industry, Helminthological Collection, Nos. 33233 and 33234.

Parona described *Histiocephalus stellae-polaris* on the basis of a single female specimen from the fulmar, *Fulmarus glacialis*, taken in the Arctic region. His very meagre illustrated description (taken from Cram (7) is as follows:

"Head with two large lips and a dilation in manner of a hood with denticulate margin. A tricuspid process a little posterior to this dilation. Male unknown. Female 16 mm. long. Anus at caudal extremity, the latter obtuse. Vulva at middle of body. Eggs oval, containing an embryo when deposited."

The specimens examined by the present writer which were collected from the same host and in the same general locality as Parona's specimen, possess characters that identify it with the latter's species; *Histiocephalus stellae-*

polaris has, therefore, been redescribed from this additional material. The erection of a new genus was considered necessary because of the absence of a swollen bulla in the cervical region, such as is present in species of *Histiocephalus*, and because of the helmet-like structure covering the head, and the peculiar structure of the posterior half of the long spicule, differing from these characters in the genera *Histiocephalus*, *Streptocara*, and *Yseria*.

III

The third lot of nematodes considered here consisted of a number of small and very delicate specimens, both males and females, collected in May, 1930, by E. B. Cram from the gizzard of a king rail, *Rallus elegans*, killed in St. Mary's County, Maryland. These have been identified as *Yseria coronata* (Molin, (8) 1860) Gedoelst, (5) 1919. From this material, it is possible to furnish a more adequate description than has been previously available.

YSERIA CORONATA (Molin, 1860) Gedoelst, 1919

Synonyms.—Spiroptera coronata Molin, 1860; *Histiocephalus coronatus* (Molin, 1860) Skrjabin, 1916.

Diagnosis.—Yseria: Body slender, delicate. Oral opening dorso-ventrally elongated, surrounded by 2 pseudolabia with 2 finger-like cuticular processes projecting anteriorly from their internal margin near the oral opening (Fig. 10). Each pseudolabium bearing near its base 2 submedian papillae and an amphid. Cephalic ornamentation in form of 4 posteriorly directed flaps, each flap divided into 3 or 5 finger-like processes (Figs. 10, 14 and 15). Body slightly constricted at base of head. Cervical papillae (Fig. 11) consisting of only a single tooth. Buccal cavity long, cylindrical. Esophagus divided into an anterior short and a posterior long portion.

Male 8 to 9.5 mm. long and 76μ in maximum width. Buccal cavity (Fig. 11) about 68μ long. Anterior muscular portion of esophagus 680μ, posterior glandular portion 1.94 mm., long. Nerve ring surrounding anterior portion of esophagus about 140μ from anterior extremity. Posterior extremity spirally coiled (Fig. 12) in a ventral direction, and gradually narrowing to a bluntly rounded point. Caudal alae terminating slightly anterior to tip of tail. At least 8 pairs of caudal papillae: 3 pairs of preanal and 5 pairs of postanal (it is possible that 1 or 2 additional pairs of caudal papillae were obscured because of the extremely coiled condition of the posterior extremity). Spicules unequal and dissimilar, the longer about 300μ long, relatively broad at the proximal end; shorter spicule about 88μ long, knob-like at proximal end, pointed at distal end.

Female 12 to 21 mm. long and 85 to 94μ in maximum width. In a specimen measuring 21 mm. long, buccal cavity 85μ long, anterior muscular portion of esophagus about 780μ, posterior glandular portion 2.42 mm., long, nerve ring 146μ and vulva 10.3 mm. from anterior extremity of body. Posterior extremity (Fig. 13) bent slightly dorsad, bluntly rounded. Anal opening 1.72 mm. from posterior end. Eggs 44μ by 17μ.

Hosts.—Chloroceryle americana (syn., *Alcedo americana*), *Rallus cayennensis*, and *R. elegans*.

Location.—Gizzard.

Locality.—South America (Brazil) and North America (United States [Maryland]).

Redescription based on specimens in U.S.N.M., Bureau of Animal Industry, Helminthological Collection No. 29839.

Drasche (9) figured (Figs. 14 and 15) and described this species as follows (translated): "Head with oval mouth opening. Two large lateral lips, each divided into 3 parts, the lateral ones bearing small papillae. Two posteriorly directed processes on each side of head, each process divided into 3 finger-like projections. Four submedian papillae. Tail of male incomplete."

Because of the lack of knowledge concerning the number of caudal papillae possessed by the male, Drasche left this species in the genus *Spiroptera* as originally placed by Molin. He stated, however, that should the posterior extremity of the male of this species possess 4 preanal caudal papillae and unequal spicules, it would belong to the genus *Histiocephalus*. Skrjabin (4) later reallocated the species to that genus, although stating that its position there was doubtful. According to the present accepted diagnosis of the genus *Histiocephalus*, the cervical region is swollen into a bulla consisting of numerous longitudinal folds; this is not the case in *Yseria coronata*.

The presence of only a single tooth on the cervical papilla differentiates this species from *Y. californica* which is said to possess cervical papillae with 3 teeth each; the male of *Y. californica* is as yet undescribed, so that comparison of the two species is limited. The generic diagnosis of *Yseria* must now be modified with respect to the cervical papillae, to designate them as each having 1 to 3 cusps; also as regards the position of the vulva, to designate it as being slightly pre-equatorial or slightly post-equatorial.

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ZOOLOGY.—*Some Actinaria from Bering Sea and arctic waters.*[1] OSKAR CARLGREN, Zoological Institute, Lund, Sweden. (Communicated by MARY J. RATHBUN.)

At the end of 1933 I received from the United States National Museum for examination a small collection of Actinaria taken by Capt. R. A. Bartlett in the course of his expeditions into arctic waters during the past decade. As our knowledge of the Actinarian fauna in the Bering Sea and in the waters continuous with it is very imperfect and every contribution to it interesting, I have taken the liberty of adding to the list of the National Museum collection some specimens from the Swedish expeditions to Kamchatka and the Aleutian Islands (designated in brackets with the letters R.M.). The descriptions of several species, previously imperfectly examined, are here somewhat extended. One species, *Epiactis ritteri* Torrey I have referred to a new genus, *Cnidopus*.

Family PTYCHODACTIIDAE

1. PTYCHODACTIS PATULA App. Mouth Kotsebue Sound, Alaska, Bartlett, 1924, 1 specimen.

The discovery of this species north of Bering Strait is very interesting as it has been taken previously only in Trondheim Fjord, north of Iceland and more recently in Malangen, Norway, at a depth of 350 m. In 1921 (Actiniaria. The Ingolf Exped., 5: 12.) I stated that the throat is not so much reduced as Appellöf described it. In fact the throat in the present specimen is 1–1.5 cm. long; the column, which is rather strongly contracted, 3 cm.

Family HALCAMPIDAE

2. HALCAMPA ARCTICA Carlgr. E. of Alger Island, Alberdare Channel, Franz Joseph Land, Baldwin-Ziegler Expedition, 1901, numerous specimens.

Family CONDYLANTHIDAE

3. CHARISEA SAXICOLA Torrey. Unalaska, Aleutian Islands in pools during the ebb, 3 specimens, Hultén, 1932 (R.M.).

This species appears to be a Condylanthid, though it is not identical with *Charisea*, as Stephenson (Quart. Journ. Micros. Soc. 66: 262.) suggests. The small specimens examined, the largest being only 0.7 cm. long, are little suited to answering this question because the proximal part of the body is introverted, but there seem to be rather distinct basilar muscles. Also the fact that there are a few more mesenteries than tentacles in the greater part of the body would seem to place the species in the family Condylanthi-

[1] Published by permission of the Secretary of the Smithsonian Institution. Received March 19, 1934.

dae. The sectioned specimen has 27 mesenteries, 6+6 pairs and 3 unpaired of the third order, one on one side of the directive plane, two on the other, but only 22 tentacles. Only the mesenteries of the first order are macrocnemes. The gonads, here ovaries, are only little developed. The nematocysts of the column are partly 15–24×4.5μ (penicilli often curved), partly 14–17 ×about 2.5μ, partly 12–13×1μ; those of the tentacles partly 17–21×3.5–4.5μ (often curved), partly 15–19×2–2.5μ (very numerous).

Family ACTINIIDAE

4. TEALIA (URTICINA) FELINA L. var. CRASSICORNIS. Cape Lisburne, Alaska, beach, H. D. Woolfe, 1835, 1 specimen; mouth Kotsebue Sound, Alaska, Bartlett, 1924, 1 specimen; 62° 15′ 20″ N., 167° 48′ W., Stoney, 1884, 2 specimens; 20 miles off Devil's Mountain, Alaska, Bartlett, 1924, 1 specimen; Wrangell, Alaska, 2 specimens; W. Greenland, 70° 20′ N., 56° W., off Hare Island, 10–15 fms., McClain, 1884, 2 specimens; N.E. Greenland, Clavering Island, 10–35 fms., Bartlett, 1930, 4 specimens; var. *coriacea*, Bering Island, L. Stejneger, 1882–83, 1 large specimen provided with distinct, although somewhat introverted, but rather large verrucae. Therefore, I think that the specimen may be *coriacea* or possibly *tuberculata*, at any rate neither *crassicornis* nor *lofotensis*.

The discovery of a tuberculated form of *Tealia* at Bering Island is very interesting as showing that in Bering Sea, as well as in the Atlantic, smooth forms occur to the north, tuberculated forms to the south.

5. CRIBRINOPSIS SIMILIS Carlgr. W. Greenland, 70° 20′ N., 56° W., 90 fms., McClain, 1884, 1 imperfect specimen.

6. BUNODACTIS SPITZBERGENSIS Carlgr. Greenland, Bartlett, 1 specimen.

7. BUNODACTIS STELLA Verr. Unalaska, Aleutian Islands, Hultén, 1932, 3 specimens (R.M.).

Verrill states, 1922 (Report Canadian Arctic Exped., 1913–18, 8. G, p. 112), that the number of tentacles may amount to 72, sometimes to 120. The present specimens are considerably larger than those previously described by me (*l.c.* 1921, p. 148) and had more tentacles. One specimen which was examined more closely is provided with about 96 tentacles and mesenteries, and its sphincter is distinctly palmate circumscript.

8. ANTHOPLEURA XANTHOGRAMMICA (Brandt). Saginaw Bay, Alaska, beach, W. H. Jones, 3 specimens; Wrangell, Alaska, 1915, 2 specimens; Bering Island, L. Stejneger, 1882–83, 1 specimen; Nikolski, Bering Island, L. Stejneger, 1897, 3 specimens; Petropaulovsk, Kamchatka, stony beach, low water, Swedish exped., 1921, 1 specimen (R.M.).

The species is described from Port Townsend by McMurrich (Ann. N. Y. Acad. 14: 36. 1901.), who, moreover, mentions that it occurs also at San Francisco. It is possible that some of McMurrich's specimens belong to

xanthogrammica, but some others may be another species. According to McMurrich, Dr. Calkins states "that evidences of multiplication by fission were not infrequent among the Port Townsend specimens." I have not found any indication of such a reproduction. The 5 specimens, taken from three localities and examined by me are provided with 96 mesenteries and about an equal number of tentacles. Also the sphincter seems to be different. In McMurrich's specimen they are palmate circumscript; in our specimens they are pinnate and resemble the sphincter of *Epiactis ritteri*, although the

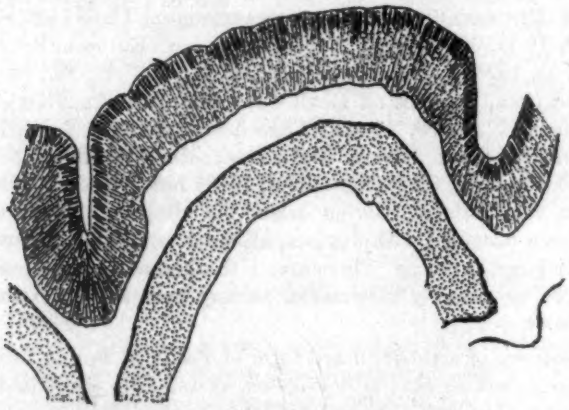

Fig. 1.—*Cnidopus ritteri*. Almost transverse section of a protuberance showing the distribution of the nematocysts (the black rods). Between the nematocysts in the middle of the protuberance are many gland cells.

main lamella here is thinner. Komai and Ikari (Records Oceanographic Works Japan 1: 120. 1929.) mention *xanthogrammica* from Tanabe Bay, not far from the southernmost point of the main island of Japan, but this may be another species, possibly *Anthopleura japonica* Verr. In our specimens, preserved in alcohol, the tentacles, including their apices, the oral disc, and the upper part of the column are greenish, the marginal sphaerules and the actinopharynx colorless, the pigment being situated in the endoderm. I have more closely examined a specimen the mesenteries of which are arranged $6+6+12+24=48$ pairs, 2 of which are directives. All mesenteries except the directives are fertile; all or almost all perfect. The pennons are considerably stronger than those figured by McMurrich and remind one of those of *Tealia felina*. The parietobasilar and the basilar muscles are strong. The marginal sphaerules are large in a specimen from Bering Island, corresponding with the endocoels as well as with the exocoels. Meanwhile, the number and size of the marginal sphaerules vary, as is common in species having such organs. In another specimen they are smaller and more sparse, and in the two specimens from Kamchatka I could not find any. It is possible, however,

that they are present but very small and few in number. The nematocysts of the marginal spherules in three specimens examined are (50) 55–67, 55–68, 55–69×3.5–4.5μ, those of the lower part of the column (one specimen examined) 18–22×2–2.5μ, those of the uppermost part 14–17×1.5–2μ, those of the tentacles 17–22×(2) 2.5μ (very numerous), those of the actinopharynx 23–26×2.5μ.

Cnidopus, new genus

Actiniid with broad pedal disc. Column smooth, in the lower part, from the limbus upward, provided with transverse and longitudinal rows of low protuberances square at the base and very close together. The sides of these protuberances and the furrows between them form strong nematocyst batteries. Sphincter circumscript. Tentacles rather short, comparatively numerous, as a rule arranged hexamerously. Longitudinal muscles of the tentacles and radial muscles of oral disc ectodermal. Mostly 2 siphonoglyphes. Mesenteries for the most part perfect, and more numerous than the tentacles. Pennons of the mesenteries not strong, parietobasilar and basilar muscles strong. Mesenteries of the first and second cycles probably sterile.

9. CNIDOPUS RITTERI (Torrey). St. Georges Island, Alaska, G. D. Hanna, 1914, 7 specimens. ? Nikolski, Bering Island, Stejneger, 1897, 1 specimen.

This species, described and referred by Torrey (Proc. Washington Acad. Sci. 4: 393. 1902.) to the genus *Epiactis* is here referred to a new genus for which I propose the name *Cnidopus* owing to the very numerous nematocysts present at the sides of the protuberances and between them in the lowest part of the column. Torrey describes the exterior of the column in the following manner: "The body-wall is smooth, without true verrucae, though near the foot there may be ten or twelve rows of protuberances which slightly resemble them. They are caused by transverse and longitudinal wrinkles and are of the same histological character as the rest of the wall. They vary greatly in size even in the same individual." (See fig. 6, pl. 25 in Torrey's paper). Our specimens show the same exterior, so that it is clear that we have to do with *E. ritteri*. Like Torrey's, our specimens are rather strongly contracted, wherefore it is probable that the protuberances, in our specimens arranged in 8–14 longitudinal rows, in the extended state have a more vesicle-like appearance. The histological structure of the protuberances is, however, other than Torrey stated. The sides of the protuberances and the furrows are provided with very numerous nematocysts standing, as in the marginal sphaerules, very close together. Only in the middle of the protuberances the nematocysts, especially the larger, are sparse or almost lacking on some protuberances more than on others. (Fig. 1). There are two sizes of these nematocysts—unfortunately they are opaque, so that I cannot decide their structure—the larger of which reach a size not observed by me in the vesicles of any one Actiniid (including Phyllactids) except in the marginal sphaerules. The size of the larger nematocysts varies in 4 specimens

between 31–41×4.5–5μ, (35–41×4.5–5μ, 32–41×4.5μ, 31–41×4.5–5μ, and in the smaller specimen 31–36×4.5μ); the smaller between 17–26×2–2.5μ (22–26×2–2.5μ, 21–26×2–2.5μ, 19–24×2–2.5μ, 17–22×almost 2.5μ in the smallest specimen). In the other parts of the column only the small nematocysts (17–24×about 2.5μ) are present, although I observed in some macerated preparations a few larger nematocysts, possibly stuck to the ectoderm. The sphincter is in all specimens pinnate circumscript, as is that figured by Torrey. The longitudinal muscles of the tentacles and radial muscles of the oral disc are well developed and palisade-like arranged. Three specimens examined have 2 siphonoglyphes and 2 pairs of directives. One specimen more closely examined has 192 mesenteries, but only 172 tentacles, thus the number of tentacles is fewer than that of the mesenteries. All mesenteries are perfect, except those of the last cycle and possibly some of the fourth. Torrey stated that the mesenteries of the last cycle were sterile, all others fertile. Although the strong contraction of the large specimen examined makes it difficult to determine exactly the distribution of the gonads, I am able to state that the mesenteries of the fifth (the last cycle), fourth, and partly those of the third cycles have ovaries; on the other hand, I have not observed any on the mesenteries of the first and second cycles. The pennons of the mesenteries are rather thin, the parietobasilar muscles broad and reaching almost the margin, the basilar muscles well developed, oral and marginal stomata present. The nematocysts of the tentacles are in 5 specimens 29–32×2.5μ; 26–30×2 (2.5) μ, 24–29×2μ, 26–31×almost 2.5μ, 19–29×almost 2.5μ (in the smallest specimen); those of the actinopharynx 27–32 ×2.5μ, 26–30×2.5μ, 26–29×2.5μ, 29–32×2.5μ (in one specimen I find also some large nematocysts 29–36×4.5–5μ, possibly stuck to the ectoderm). The penicilli of the filaments are in one specimen 26–31×4.5–5μ, the spirocysts of the tentacles 22–43×2.5—almost 3.5μ, 22–41×3.5μ (2 specimens examined).

Family ACTINOSTOLIDAE

10. STOMPHIA COCCINEA (O.F.M.). Coal station near Cape Lisburne, Alaska, beach after 4 days of N.W. gale, H. D. Woolfe, 1885, 3 specimens; Saglek Bay, Labrador, Bartlett, 1925, 1 specimen.
11. ACTINOSTOLA SPITZBERGENSIS Carlgr. Mouth Kotsebue Sound, Alaska, Bartlett, 1924, 1 specimen; 20 miles off Devil's Mountain, Alaska, 16–18 fms., mud bottom, Bartlett, 1924, 2 specimens; Clavering Island, N.E. Greenland, 10–35 fms., Bartlett, 1930, 1 specimen.

Family HORMATHIIDAE

12. HORMATHIA NODOSA (Fabr.). Entrance to Fury & Hecla Straits, Baffin Land, Norcross & Bartlett, 1933, 1 specimen; Saglek Bay, Labrador, Bartlett, 1925, 1 specimen; 70° 20′ N. off Hare Island, W. Greenland, 2 specimens; Clavering Island, N.E. Greenland, 10–35 fms., Bartlett, 1930, 3 small specimens; Greenland, Bartlett, 1 specimen; 80° 22′, N.W.

coast of McClintock Island, Franz Joseph Land, Baldwin-Ziegler Exped., 1902, 1 specimen.

13. METRIDIUM SENILE (L.) var. FIMBRIATUM. St. Michaels, Norton Sound, Alaska, E. W. Nelson, 1879–80, low water, 3 specimens; Unalaska, Aleutian Islands, Hultén, 1932, 5 specimens (R.M.); Petropaulovsk, Kamchatka, Swedish Kamchatka Exped., 1921, 4 specimens (R.M.); Awatcha Bay, Swedish Kamchatka Exped., 1921, some small specimens (R.M.); Achomten Bay, Swedish Kamchatka Exped., 1920, 1 specimen (R.M.).

Among the specimens from Unalaska there is a small one (0.5×0.6 cm.), the nematocysts of the acontia of which are: Penicilli 47–58×about 5μ, spirulae 47–57×3–3.5μ. In a small specimen of the variety *dianthus* of about the same size as the variety *marginatum* the penicilli of the acontia are 46–50 ×almost 5.5μ, the spirulae 38–50×3–3.5μ. Thus it seems that also young specimens of *marginatum* have larger nematocysts than *dianthus* in the acontia (compare Carlgren, *The Godthaab Exped.*, 1928. Medd. om Grønland **79**: 23–24. 1933.).

ZOOLOGY.—Neodiplostomum pricei *n.sp., a new trematode from a gull*, Larus novaehollandiae.[1] WENDELL H. KRULL, Bureau of Animal Industry. (Communicated by MAURICE C. HALL.)

The fluke described in this paper was obtained from an Australian silver gull, *Larus novaehollandiae* Stephens, which had been experimentally infected by feeding it fish, *Fundulus diaphanus diaphanus* and *F. heteroclitus macrolepidotus*, containing metacercariae of the neascus type. The species appears to be new and for it the name *Neodiplostomum pricei* is proposed.

Neodiplostomum pricei n. sp.

(Figs. 1–2)

Description.—Neodiplostomum: Body small, distinctly separated by constriction into a forebody and hindbody. Forebody 1.2 mm. to 1.6 mm. (average 1.4 mm.) long by 600μ to 665μ (average 632μ) wide, spoon-shaped, relatively thin and leaf-like, without glands and lateral sucking cups; hindbody 550μ to 880μ (average 748μ) long by 410μ to 520μ (average 472μ) wide, roughly cone to acorn-shaped when bursa copulatrix is withdrawn. Cuticula provided with fine spines extending from anterior end to level of holdfast organ. Oral sucker 37μ to 60μ (average 47μ) long by 30μ to 44μ (average 38μ) wide and subterminal. Mouth opening into a short prepharynx about one-third as long as pharynx. Pharynx 33μ to 53μ (average 43μ) long by 26μ to 41μ (average 33μ) wide. Esophagus twice as long as pharynx, bifurcating to form narrow, thin-walled ceca extending to near level of posterior end of posterior testis; ceca ventral in position in hindbody. Acetabulum 55μ to 92μ (average 76μ) long by 73μ to 112μ (average 91μ) wide, midway between

[1] Received April 17, 1934.

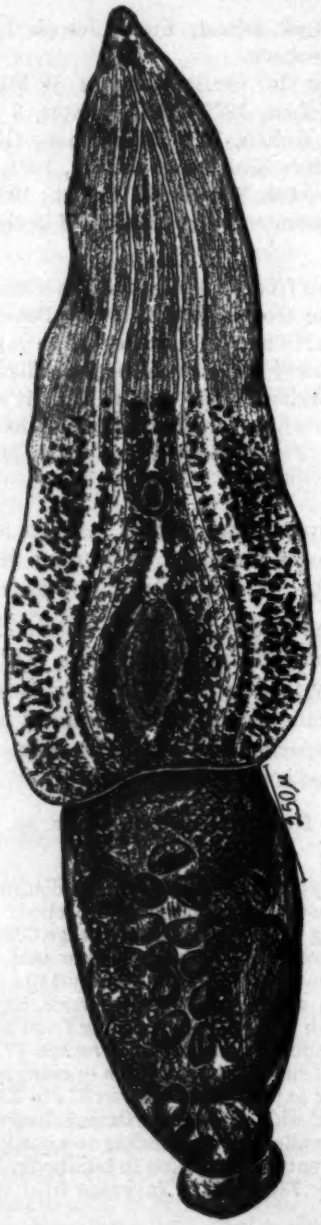

Fig. 1.—*Neodiplostomum pricei*. Entire worm.

holdfast organ and anterior end of vitelline area. Holdfast organ large, 310μ long when extended (Fig. 2b), with median longitudinal cleft when retracted. Testes large, tandem, filling greater part of hindbody; anterior testis 230μ to 318μ (average 280μ) long by 295μ to 425μ (average 387μ) wide, transversely oval; posterior testis 280μ to 360μ (average 330μ) long by 372μ to 470μ (average 435μ) wide, reniform, wider than long, somewhat larger than anterior testis. Vas deferens broad and extending to near posterior end of posterior testis, expanding there and forming a voluminous, folded seminal vesicle filled with spermatozoa, discharging into genital atrium through a

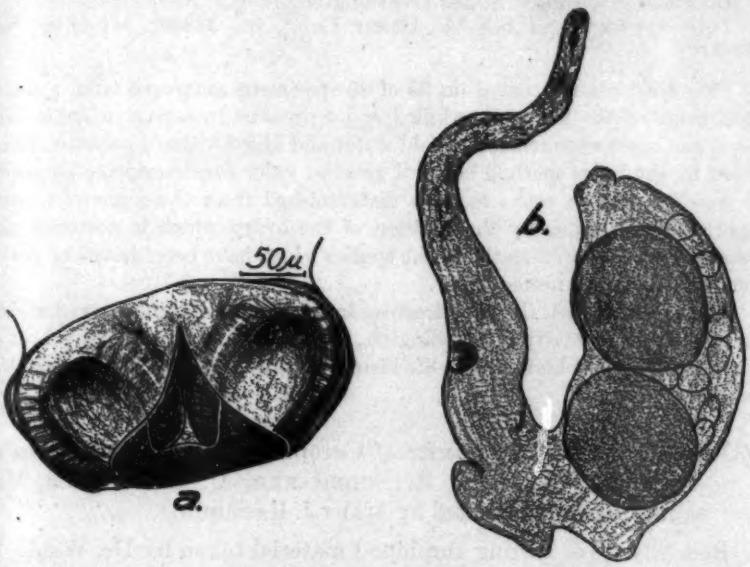

Fig. 2.—*Neodiplostomum pricei*. (*a*) Bursa copulatrix, expanded, dorsal view; (*b*), complete specimen flexed dorsally, showing expanded hold-fast organ.

short ejaculatory duct. Ovary 110μ to 140μ (average 120μ) long by 86μ to 122μ (average 104μ) wide, ventral, either to right or left of median line, at, and usually overlapping postero-lateral margin of anterior testis. Oviduct arising on postero-dorsal face of ovary, continuing in postero-dorsal direction and uniting with Laurer's canal, turning, continuing somewhat anteriorly, uniting with common vitelline duct, and then continuing as oötype. Laurer's canal opening dorsally in median line near level of posterior margin of ovary. Mehlis' gland large, surrounding oötype. Uterus voluminous, with short ascending limb turning at level of anterior testis and continuing posteriorly as descending limb, extending in median line ventral to all organs except vitellaria, and terminating at genital atrium. Proximal portion of uterus usually filled with spermatozoa, and in stained and mounted specimens sometimes folded in such a way as to appear as a spherical seminal receptacle equal in size to, and opposite, ovary. Vitellaria occupying area from middle of anterior body to end of posterior testis; vitelline follicles extending dorsally and ventrally in anterior body and in portion of posterior

body in front of anterior testis, and ventrally in remaining part of posterior part of body; vitelline follicles in anterior part of body relatively small, and those in posterior part very large. Common vitelline duct with mostly a dorso-ventral course; expanded to form a vitelline reservoir. Eggs from preserved flukes averaging 86μ long by 66μ wide, those from living flukes averaging 92μ long by 72μ wide. Details of bursa copulatrix shown in figure 2a.

Host.—*Larus novaehollandiae* Stephens (experimental).

Location.—Small intestine.

Distribution.—United States (Washington, D. C.)

Type specimens.—U.S.N.M. Helm. Coll. No. 32880; *paratypes* No. 32881.

This description is based on 25 of 80 specimens recovered from a single gull. Some of the flukes were killed under pressure in corrosive acetic fixative, and some were relaxed in cold water and killed without pressure, those fixed by the latter method being of greatest value for descriptive purposes.

Neodiplostomum pricei may be distinguished from the numerous other species of the genus by the position of the ovary which is posterior and lateral to the anterior testis. In the species which have been described previously the ovary is pretesticular.

The gull, in which the experimental infection was obtained, was hatched and raised in captivity in Washington, D. C. The natural definitive host of the parasite is not known. The life history of this parasite will be given elsewhere.

ZOOLOGY.—*Two new species of* Corophium *from the west coast of America.*[1]

CLARENCE R. SHOEMAKER, U. S. National Museum. (Communicated by MARY J. RATHBUN.)

Recently while sorting amphipod material taken by Dr. Waldo L Schmitt along the coast of Peru in 1926, I noticed an undescribed species of *Corophium* which I here designate as *Corophium baconi.*

In 1927 the Pacific Biological Laboratories sent to the United States National Museum some amphipods from Monterey Bay, California, amongst which was another species new to science which I here designate as *Corophium californianum.*

Corophium baconi, new species

Figure 1

Description of male.—Head with rostrum short and broadly triangular; eye lobes broad, their front margin nearly straight and gradually passing into side margin of head by a broadly rounding curve. Antenna 1, first joint about as long as second plus half of third, lower margin with one distal spine and two about one-third from the proximal end, though the third or proximal

[1] Published by permission of the Secretary of the Smithsonian Institution. Received March 3, 1934.

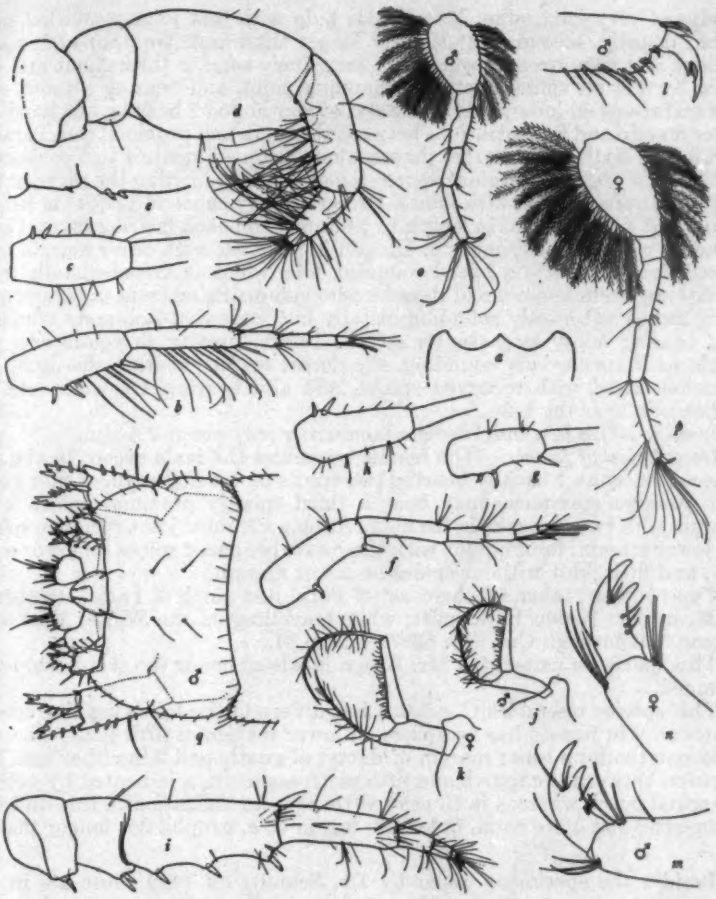

Fig. 1.—*Corophium baconi*, new species. *a*, rostrum and eye lobes, ♂. *b*, antenna 1 ♂, showing lower spines. *c*, antenna 1 ♂, top view. *d*, antenna 2 ♂. *e*, lower margin antenna 2 ♂ showing the two proximal spines. *f*, antenna 1 ♀, showing lower spines. *g*, antenna 1 ♀ showing the occasional third lower spine. *h*, antenna 1 ♀, top view. *i*, antenna 2 ♀. *j*, *k*, mandibular palp ♂ and ♀. *l*, gnathopod 1 ♂. *m*, *n*, gnathopod 2 ♂ and ♀. *o*, *p*, peraeopod 5 ♂ and ♀. *q*, fourth and fifth abdominal segments and their appendages ♂.

spine is usually lacking in younger males, inner or median edge of joint with two spines near proximal end, flagelum with four joints, the last of which is very small. Antenna 2 short and very robust, fourth joint over half as high as long with two lower distal teeth and one or two short spines on lower inner margin not far from the third joint, fifth joint with long, strong tooth very near center of inner side and a long downward-curved tooth on inner side of distal end of joint, lower margin of fifth joint and flagellum provided with

groups of very long setae. Mandibular palp with first joint somewhat produced distally, second joint slightly longer than first. Gnathopod 1, palm oblique and very broadly rounding, very finely serrate throughout and defined by a stout spine, dactyl overlapping palm, and bearing a tooth and fine serrations on inner margin. Dactyl of gnathopod 2 bearing one tooth on inner margin and fine serrations between the tooth and proximal end. Peraeopod 5 with sixth joint shorter than second. Pleon segments 4 to 6 coalesced, but there is a slight marginal depression or notch indicating the division between the fourth and fifth joints. Uropod 2 very short and equal in length to uropod 3, rami equal in length to peduncle and each bearing several long slender spines on outer margin. Uropod 3, peduncle with outer margin produced backward into a broad rounding lobe which is armed distally with three long slender spines and three slender spines arising from the upper surface, ramus not evenly rounding distally but somewhat obliquely truncate and bearing many long slender spines. Telson forming an equilateral triangle with apex evenly rounding, the dorsal surface bearing the usual depression edged with recurved spines, and also bearing a slender seta on either side near the base.

Length.—This is a small species measuring only about 2.5 mm.

Description of female.—The female resembles the male except in the antennae. Antenna 1 usually bearing two spines on lower margin of first joint, but younger specimens may bear a third smaller proximal spine, inner margin with two spines as in the male. Antenna 2, third joint with two spines on lower margin, fourth joint with three evenly-spaced spines on lower margin, and fifth joint without spines on lower margin.

Type.—Male, taken off the coast of Peru, just north of Paita, October 8, 1926, by Dr. Waldo L. Schmitt, while travelling on the Walter Rathbone Bacon Scholarship. Cat. No. 66871 U.S.N.M.

This species is named for Mr. Bacon in whose honor the scholarship was founded.

This species resembles *C. acutum* but differs in the following characters: Antenna 2 in female has no spines on lower margin of fifth joint. There is only one tooth on inner margin of dactyl of gnathopod 2 in either sex. The division between the fourth and fifth pleon segments is indicated by a slight marginal notch whereas in *C. acutum* there is no indication of this division. Uropods 2 and 3 are equal in length, but in *C. a.* uropod 2 is longer than 3.

Besides the specimens taken by Dr. Schmitt off Peru there are in the National Museum collection three male specimens from Venice, southern California, one male from Santa Monica, southern California, collected by Dr. F. C. Clark, and one male from *Albatross* Station 3253, Bering Sea, June 14, 1890.

In one of the males from Venice, which is quite large, there are three proximal spines on the under margin of the first joint of antenna 1 and three spines on median edge. The tooth on the fifth joint of antenna 2 is longer and narrower than in the Peruvian specimens and is situated beyond the center of the joint so that it does not oppose the large terminal tooth of the fourth joint. In the male from Bering Sea there are three spines on the lower margin of first joint of antenna 1. The tooth on the fifth joint of antenna 2 is just slightly on the proximal side of the center, and the inside terminal tooth of

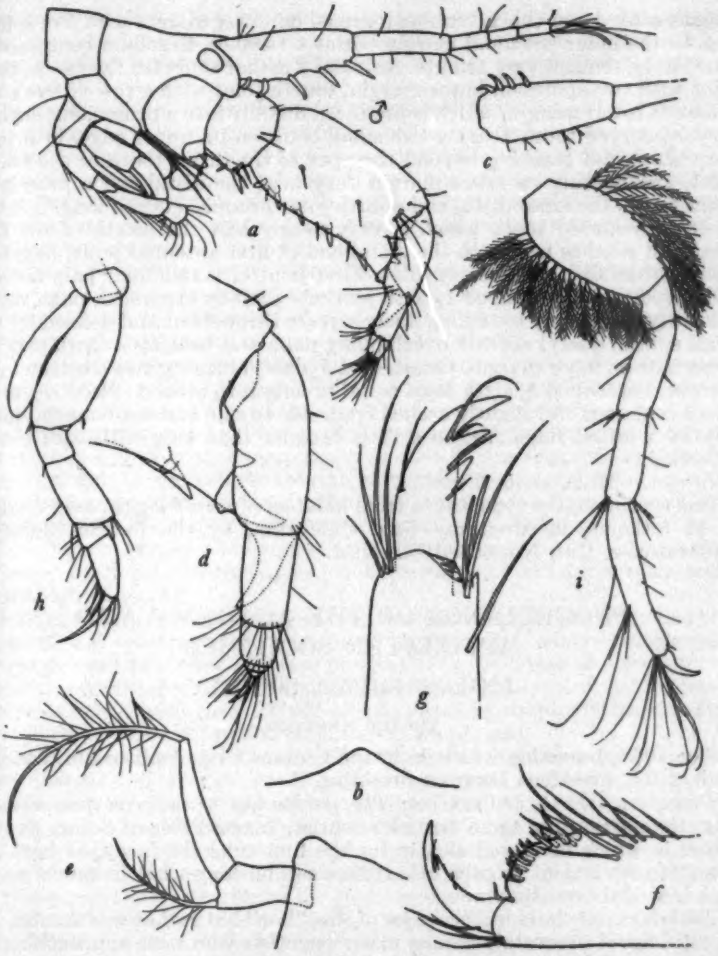

Fig. 2.—*Corophium californianum*, new species, male. *a*, head and antennae. *b*, rostrum. *c*, antenna 1, top view. *d*, antenna 2, greatly enlarged. *e*, mandibular palp. *f*, gnathopod 1. *g*, gnathopod 2. *h*, peraeopod 1. *i*, peraeopod 5.

this joint is short and blunt. The notch on the margin of the pleon indicating the division between the fourth and fifth joints is deeper and more noticeable than in the southern specimens

Corophium californianum, new species

Figure 2

Male.—Rostrum very broadly triangular. Eye-lobes rather long, curved downward and distally rounding. Eyes oval, black. Antenna 1, first joint is

long as second and third combined, armed on lower margin with five spines, and on the inner proximal margin with four spines, flagellum composed of four joints, the last very minute. Antenna 2 rather short for the genus, third joint with two spines on lower margin, fourth joint with a row of five stout spines on lower margin, which is produced distally into a prominent, slightly upward-curved tooth bearing two small teeth on its upper edge, fifth joint very short, not reaching beyond the apex of the distal tooth of the fourth joint, and bearing on lower margin very near the distal end a prominent blunt tooth, the inner distal end of fifth joint produced into a long, pointed, downward-curved tooth which is very nearly half the length of the fifth joint and reaches nearly to the distal end of first antennal joint, flagellum shorter than fifth peduncular joint. First joint of mandibular palp not distally produced. Gnathopod 1, sixth joint not distally expanded, palm rather narrowly and evenly rounding, finely serrate throughout and defined by two stout spines, dactyl slightly overlapping palm and bearing a tooth and fine serrations on inner margin. Gnathopod 2, dactyl bearing two teeth on inner margin. Peraeopod 5, sixth joint equal in length to second. Pleon segments 4 to 6 coalesced and slightly arched from side to side and not bounded laterally by a raised ridge. Telson a little broader than long with apex evenly rounding.

Length.—Male, about 3 mm.

One specimen, the type, taken from holdfast of water-logged kelp dredged in 48 fathoms, in Monterey Bay, California, by the Pacific Biological Laboratories. Cat. No. 66880 U.S.N.M.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1063RD MEETING

The 1063rd meeting was held in the Cosmos Club Auditorium, January 20th, 1934, President DRYDEN presiding.

Program: H. C. DICKINSON: *The mechanism of material prosperity.*—Less than a century ago a British scientist, James Prescott Joule, wrote a paper in which he stated clearly for the first time the fact that heat and work are equivalent to each other, thus establishing what is known as the first law of thermodynamics.

Joule was not the sole discoverer of this "law" but rather was the first one to establish it accurately among many scientists who were approaching the same solution from various points of view.

About 50 years ago another scientist, J. Willard Gibbs, professor at Yale University, was the first to formulate accurately the second law of thermodynamics. Gibb's work was translated into German and not until 15 years later did Americans know its worth after German scientists had appreciated what it meant in the field of science.

Thus was laid the foundation for the modern science of thermodynamics which is the foundation of the world's present growth in the production of power with all that this means in comfort and plenty.

Thermodynamics is a statistical science and men have long known that its basic laws must apply in other fields. National or world economics presents statistical problems which are in some ways similar to those of thermo-

dynamics. However, few economists are familiar with the natural sciences, and few physicists and engineers have been interested in economics, so there has been heretofore little chance of bridging the gap between the two sciences.

In the last few years, however, the economic convulsion of the world has turned the attention of many students of the natural sciences to economic questions. Thus, as 100 years ago, so now is there a wave of thought focused, this time not on *heat and work* but on *work and money*. Out of this thought there has emerged a new science to which we have given the name of *econodynamics*, a study of the basic laws of economics or, more specifically, of the relationship between *work and money*.

Some of the similarities between the science of thermodynamics and the newer one of econodynamics are striking. One starts out in each case with "conservation." Conservation of matter and of energy are well known laws of nature. "Conservation of money" parallels them.

The last is, however, more complex; matter and energy are fixed by nature, money by men. But it turns out that man must fix money so that the law of conservation holds, or else the money is no longer *good money*.

Similar comparisons hold for the first and second laws of thermodynamics. The second law of econodynamics states that in any economic system (nation or world) in which men are free to spend their money, it is impossible continuously to maintain any price above the normal competitive level without supplying money or work from outside the system.

The "law of supply and demand" defines what may be termed an econodynamic potential, showing in which direction price will move when either or both are changed.

To illustrate some of the subject matter of econodynamics, there has been designed and constructed a mechanical model known as an *economostrator*. It was devised purely as a means of visualizing the ideas of scientists, engineers, and others who have applied this new type of scientific analysis to economic problems during the past several years. It has proved illuminating, even to those who are familiar with the entire process.

The whole economic problem can be summed up in a few words. There are three essentials in the problem like pressure, volume and temperature for a gas, or current, voltage and resistance for electricity. These are *payrolls*, *capital*, and *debts*. There is a certain optimum relationship between them which yields a maximum net national income and no one of them can be increased beyond this point without decreasing the net income and shortly decreasing all three elements as the entire system starts downhill.

Almost the only new element in the analysis is the fact, seemingly shown now for the first time, that this optimum relationship is unstable. When the system starts out of balance the result is to increase this unbalance. The system, as it is depicted by the economonstrator, is such that a small surplus of savings must always go into capital and debts or else prosperity will decline through depletion of capital. If this surplus is allowed to continue, however, the system will be unbalanced in the other direction and prosperity will decline through an overburden of interest on debts.

In the ordinary case of business cycles this unbalance goes only about so far and corrective forces bring it back through the wiping out of the surplus savings which have gone into capital and debts. However, if the corrective forces which are mainly failures, defaults and foreclosures, do not go far enough, then the main instability of the system becomes apparent and the whole gradually collapses. Once these factors are recognized, business cycles

and national declines can be put under control by simple processes which have been worked out in some detail.

If both short cycles and economic declines were prevented, it may be seen that nearly all the serious faults of the capitalistic system would vanish. The main cause of international friction and war would disappear in the same way, as would unemployment and poverty; except that no one can ever expect to have more than he can produce unless some one else gives it to him. (*Author's abstract.*)

The following informal communication was presented.

F. G. BRICKWEDDE: The vapor pressure of a sample of nearly pure molecular deuterium in its solid and liquid states was compared with the vapor pressure of ordinary hydrogen. The following table is a brief of the results:

T	The Vapor Pressures of Ordinary Hydrogen	Deuterium	
20.38°K	76.0 cm. of Hg	26.	Boiling Point of Ordinary Hydrogen
18.6	42.9	12.	Triple Point of Deuterium
14.0	5.4	0.5	Triple Point of Ordinary Hydrogen

(*Author's abstract.*)

1064TH MEETING

The 1064th meeting was held in the Cosmos Club Auditorium, Saturday, February 3rd, 1934, President DRYDEN presiding.

Program: P. R. HEYL: *The composition of harmonic motions.*—All cases of composition of harmonic motions may be divided into two classes on the basis of energy considerations, designated respectively as conservative and non-conservative.

To the first class belong sound and light waves; to the second, alternating electric currents and tidal phenomena. In the conservative class the energy of the resultant must be equal to the sum of the energies of the constituents; in the non-conservative class this is not the case.

The conservative class may again be divided into two groups. In the first group the component running waves move in opposite directions; in the second, they move in the same direction.

The principle of superposition of amplitudes, applied to the case of oppositely running waves, gives results consistent with the principle of the conservation of energy; but applied to the case of similarly running waves gives rise to a contradiction. In such cases composition must take place by addition, not of amplitudes, but of energies. (*Author's abstract.*)

Discussed by Messrs. DRYDEN, GISH, TUCKERMAN, CURTIS, HUMPHREYS, DICKINSON, and HAWKESWORTH.

H. A. MARMER: *Tides that follow the sun.*—At most places the tide follows the moon in coming later each day by about fifty minutes on the average. On the basis of gravitation, this finds explanation in the fact that the tide-producing power of a heavenly body varies directly as its mass and inversely as the cube of its distance from the earth. Hence the moon plays the leading role in bringing about the tide.

There are some places, however, at which the tide appears to follow the sun rather than the moon. Tahiti in the Society Islands and Tuesday Island in Torres Strait are examples. At these places high and low water do not come later each day by fifty minutes on the average; instead, the tide comes at about the same time day after day. Such tides are therefore primarily solar tides.

The existence of solar tides is explained in entirely different ways by each of the two theories that have been proposed for the mechanism of the tides on our earth. The progressive-wave theory—the older—regards the tides of the open ocean as progressive waves which are derived from the primary tide waves of the Southern Ocean. Solar tides according to this theory occur at places where two progressive waves meet under the condition that they have approximately equal ranges, but differ six hours in time. Under such conditions the lunar high water of one wave is neutralized by the lunar low water of the other, and thus permits the solar constituent to become the predominant constituent. Tides at such places therefore present the features of solar tides.

The more recent theory of the tide, known as the stationary-wave theory, conceives the response of the ocean waters to the tide-producing forces to consist of stationary-waves, rather than progressive waves. According to this theory the dominant tides of the world arise from stationary-wave oscillations which are set up and maintained in various portions of the oceans by the periodic tide-producing forces of sun and moon. And since the periods of these forces differ, different portions of the oceans will respond in different ways, on account of resonance. In other words the axis of oscillation of an oceanic system responding to the solar forces will not necessarily coincide with the axis of a lunar oscillating system.

On this latter theory, therefore, solar tides in the open sea are explained as occurring in regions which lie near the axis of a lunar oscillating system, but at some distance from the axis of a solar oscillating system. The rise and fall of the lunar constituent at such places is small, and this gives the solar constituent the opportunity to become the dominant constituent of the tide. (*Author's abstract.*)

Discussed by Messrs. LIFEROCK, TUCKERMAN, HAWKESWORTH, BITTINGER, HULBURT, HUMPHREYS, MCNISH, and HEYL.

1065TH MEETING

The 1065th meeting was held in the Cosmos Club Auditorium, Saturday, February 17th, 1934, President DRYDEN presiding.

Program: R. J. SEEGAR: *The physical nature of the chemical bond.*—The speaker reviewed the historical development of our ideas concerning the nature of the covalent chemical bond and presented the mathematical theory of the Quantum Mechanics used in the calculations of the energy of two atoms held together by such a bond. (*Secretary's abstract.*)

Discussed by Messrs. DRYDEN, HAWKESWORTH, GIBSON, MAXWELL, HUMPHREYS, TUCKERMAN, and HAFSTAD.

1066TH MEETING

The 1066th meeting was held jointly with the Washington Academy of Sciences, in the Cosmos Club Auditorium, Saturday, March the 3rd, 1934. L. B. TUCKERMAN, president of the Academy presided.

The program consisted of an address entitled *Remarks on catalysis* by James Franck, formerly director of the Second Physical Institute at the University of Göttingen.

The abstract of this address will be published in the PROCEEDINGS OF THE ACADEMY.

Discussed by Messrs. MOHLER, WULF, HUMPHREYS, TUCKERMAN, L. H. ADAMS, and R. E. GIBSON.

1067TH MEETING

The 1067th meeting was held in the Cosmos Club Auditorium, Saturday, March 17th, 1934, President DRYDEN presiding.

The program consisted of an address by J. H. TAYLOR: *The process of generalization in mathematics as exhibited in the development of the Frenet formulae.*—Beginning with elementary considerations of the representation of points and directions in a three dimensional space, transformations of coordinate systems and the correspondence of points and directions were discussed, and the Frenet Formulae then developed. The three dimensional case was generalized, and the same procedure carried through for an n-dimensional space representing n-variable quantities or properties, and the more general, Frenet formulae for an n-dimensional space were derived. (*Secretary's abstract.*)

Discussed by Messrs. DRYDEN, HAWKESWORTH, DANTZIG, TUCKERMAN, MUNK, HOPPMAN, HUMPHREYS, SEEGAR, BLAKE, GIBSON, and SEARLES.

1068TH MEETING

The 1068th meeting was held in the auditorium of the Cosmos Club, March 31, 1934, President DRYDEN presiding.

The program consisted of the fourth Joseph Henry Lecture. This was given by Professor OSWALD VEBLEN of Princeton University, on the subject of *Spinors.*

This lecture has been published in full in this JOURNAL 21: 281. 1934.

Discussed by Messrs. HAWKESWORTH, TUCKERMAN, DANTZIG, ADAMS, SEEGAR, BRIGGS, and GISH.

1069TH MEETING

The 1069th meeting was held in the Cosmos Club Auditorium, April 14, 1934, President DRYDEN presiding.

Program: J. W. MCBURNEY: *The indentation of asphalt tile.*—A formula was presented for relating the depth of indentation to the time during which a loaded sphere acts upon such a plastic body as an asphalt tile. Data were presented showing the effect of varying the diameter of the sphere and the load. A portable instrument for indentation testing was described. The use of these test methods in technical specifications for asphalt tile was discussed. (*Author's abstract.*)

Discussed by Messrs. DRYDEN, BRIGGS, LEDIG, and GISH.

W. G. BROMBACHER: *Altitude in airplane and balloon flight.*—In making an international record for altitude in airplane and balloon flights the lowest pressure attained is measured and not the altitude. This pressure is probably the best simple measure of the performance of the airplane in view of the fact that the air temperature varies but little at the altitudes now necessary to break the unlimited record for altitude. The lowest pressure is converted to altitude by means of the altitude-pressure relation of the F. A. I. standard atmosphere which has been adopted internationally for such use.

A barograph is used to secure a record of air pressure against time. It is mounted in the aircraft from an elastic suspension. The trace is made by a stylus operating on a smoked chart of paper or aluminum sheet. Many barographs contain an element for recording the instrument temperature.

In this country the barograph is tested at the Bureau of Standards. The test consists essentially in subjecting the barograph to a flight history test, during which the conditions of the flight as to instrument temperature and

air pressure are reproduced. The lowest indicated pressure is measured by a mercurial barometer of the altitude type.

Details of record breaking flights are given in the following tables:

AIRPLANE FLIGHTS TO HIGHEST ALTITUDE

PILOT	COUNTRY	DATE	LOWEST PRESSURE	CORRESPONDING FAI ALTITUDE
			mm. Hg.	Feet
J. A. Macready	U. S.	Sept. 28, 1921	178	34563
S. Lecointe	France	Oct. 30, 1923	161.5	36555
J. A. Macready	U. S.	Jan. 29, 1926	146	38704
C. C. Champion	U. S.	July 25, 1927	147.5	38491
St. C. Streett and A. W. Stevens	U. S.	Oct. 10, 1928	152	37854[1]
A. Soucek	U. S.	May 8, 1929	143	39140
W. Neuenhofen	Germany	May 25, 1929	126	41794
A. Soucek	U. S.	June 4, 1930	118	43166
C. F. Unwins	England	Sept. 16, 1932	113.5	43976
G. Lemoine	France	Sept. 28, 1933	109	44822

[1] By barometric formula from pressure and temperature observations 39606 feet. By camera method 39250 feet.

SEAPLANE FLIGHTS TO HIGHEST ALTITUDE

PILOT	COUNTRY	DATE	LOWEST PRESSURE	CORRESPONDING FAI ALTITUDE
			mm. Hg	Feet
S. Lecointe	France	March 11, 1924	225	29462
V. Demougeot	France	March 28, 1927	215	30479
C. C. Champion	U. S.	July 4, 1927	151	37995
A. Soucek	U. S.	June 4, 1929	147	38560

BALLOON FLIGHTS TO HIGHEST ALTITUDE

(OPEN GONDOLA)

PILOTS	COUNTRY	DATE	LOWEST PRESSURE	CORRESPONDING FAI ALTITUDE
			mm. Hg	Feet
Suring and Berson	Germany	July 31, 1901	170.5(?)	35424 (10800 m.)
H. C. Gray	U. S.	March 9, 1927	235	28510
H. C. Gray	U. S.	May 4, 1927	122	42470[1]
H. C. Gray	U. S.	Nov. 4, 1927	122	42470[2]

[1] Not recognized as a record because Capt. Gray jumped from balloon before landing.

[2] Not recognized as a record. Capt. Gray was found dead in the gondola and it was therefore presumed that he did not navigate the balloon to a landing.

STRATOSPHERE BALLOON FLIGHTS

PILOTS	COUNTRY	DATE	VOLUME OF BALLOON	LOWEST PRESSURE	CORRESPONDING FAI ALTITUDE
			Cu. ft.	mm. Hg	Feet
Piccard and Kipfer	Belgium	May 27, 1931	141,000	78	51775
Piccard and Cosyns	Belgium	Aug. 18, 1932	500,000	73	53153
Prokovieff, Birnbaum and Godounoff	Russia	Sept. 30, 1933	860,000	49–50	62300(?)
Settle and Fordney	U. S.	Nov. 20, 1933	600,000	49.5	61237
Fedossenko, Vasenko, Usiskin	Russia	Jan. 30, 1934	882,850	—	72178(?)

(*Author's abstract.*)

Discussed by Messrs. DRYDEN, STIMSON, DICKINSON, HAWKESWORTH, and LEDIG.

1070TH MEETING

The 1070th meeting was held in the Cosmos Club Auditorium, May 12, 1934, President DRYDEN presiding.

The program for the evening consisted of an address, *The thunderstorm and its electrical effects*, by B. F. J. SCHONLAND of the De Beers Institute of Physics and Mathematics, University of Cape Town, South Africa.

Little progress has been made in the study of thunderstorm electricity until it was placed on a quantitative basis by Prof. C. T. R. Wilson and his school in 1919. The recent measurements of the electric moment of lightning discharges give average values of about 80 coulomb-kilometers for this quantity. It follows that the charge destroyed by a flash is of the order of 20 coulombs. It can then be deduced without ambiguity that the potential difference developed by the average thundercloud is some billions of volts and that the continuous rate of generation of electrical energy is about 3×10^6 kilowatts. Approximately half of this is spent in the form of lightning, the remainder being devoted to the supply of dissipation or leakage currents above and below the cloud. These currents are of considerable importance in that they appear to feed a positive charge from earth to upper atmosphere and thus to provide a satisfactory mechanism for the maintenance of the permanent electric field which prevails all over the earth in fine weather.

In the discussion of the genesis of these currents—point discharge from the earth and cumulative ionization in the upper air—certain interesting deductions emerge. Thus the space charge above the earth makes it difficult for the field at the earth's surface to reach values required for the initiation of a lightning discharge. Again the thunderstorm should, as Prof. Wilson has pointed out, be capable of producing considerable additional ionization in the Kennelly-Heaviside layer. Experimental evidence on these questions supports the deductions made. The thunderstorm origin of most atmospherics

and the application of this knowledge were briefly dealt with, together with the experimental evidence for the production by thunderclouds of an upward-moving spray of penetrating electrons.

The preliminaries to the lightning discharge have recently been studied photographically by a Committee of the South African Institute of Electrical Engineers. The discharges examined have so far all been from a negative cloud pole to the ground, the most frequent case. They reveal the presence of downward electron moving avalanches and will, it is hoped, enable the mode of progression of such avalanches to be studied in detail on a large scale. (*Author's abstract.*)

Discussed by Messrs. GISH, MOHLER, SILSBEE, WHITE, HUMPHREYS, GIBSON, TUCKERMAN, and BRICKWEDDE.

F. G. BRICKWEDDE, *Recording Secretary*

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

NOTES

National Bureau of Standards.—Dr. LYMAN J. BRIGGS, Director of the National Bureau of Standards, left Washington on July 6 for the balloon camp near Rapid City, South Dakota, to witness the stratosphere flight under the auspices of the National Geographic Society and the U.S. Army Air Corps. Dr. BRIGGS is chairman of the Advisory Committee for the Flight, appointed by President GROSVENOR of the National Geographic Society. He has given a great deal of time to the plans for the flight, particularly in connection with the scientific instruments carried.

Dr. H. J. MCNICHOLAS has returned to his former work in the organic and fibrous materials division on X-ray investigations of the structure of fibers from farm waste.

Dr. J. H. DELLINGER, chief of the radio section, has enlisted the cooperation of owners of short-wave radio sets, in a world-wide investigation to discover the origin of long-delay radio echoes. Two high-power high-frequency stations are transmitting special signals to facilitate observations. They are GSB, Daventry, England, and HBL, the League of Nations station in Geneva, Switzerland. GSB transmits a 1,000-cycle note on a frequency of 9510 kilocycles each Sunday, Tuesday and Thursday, from 3:25 to 3:55 A.M., Eastern Standard Time and HBL transmits on 6675 kilocycles each Sunday, Wednesday and Friday from 6:00 to 6:30 A.M. EST. The familiar round-the-world echo occurs one-seventh of a second after the original signal, the time required for the wireless wave to circle the earth. The long-delay echoes being studied may occur as much as three seconds after the primary signal.

An investigation of the paper used for Braille books for the blind has resulted in the discovery that use of paper with a maximum tensile strength produces Braille dots that stand up during a long life and do not crack and irritate sensitive finger tips of blind readers.

Bureau of Biological Survey.—Changes in the Wildlife Bureau, including the consolidation of the Divisions of Game and Bird Conservation and Predatory Animal and Rodent Control, and establishment of a Migratory Waterfowl Division and Public Relations Unit, have been announced.

Public Health Service.—Headed by Dr. JAMES P. LEAKE, veteran of the Service, a party of investigators including Drs. E. T. CEDER, A. G. GILLIAM and W. P. DEARING has left for California to lend their aid in the great battle against infantile paralysis being waged in that state.

For over a year Dr. W. T. HARRISON of the U.S. Public Health Service has been working on a vaccine to give protection against infantile paralysis. He has already had "encouraging" results in protecting monkeys with the vaccine, but he is not yet ready to try it on humans. The vaccine is made by a special technic which officials of the U.S. Public Health Service are not willing to report at present.

Weather Bureau.—Beginning in July, the U.S. Weather Bureau will make routine weather observations by airplane on a much larger scale than heretofore practiced. From twenty different airports, pilots will make observation flights to high altitudes, carrying a meteorograph which automatically records humidity, temperature, and pressure.

NEWS BRIEFS

Giant map-making camera.—The world's largest camera, 31 feet long and weighing fourteen tons, has just been placed in operation reproducing nautical charts and airway maps. So precise is the work of this huge camera, which resembles a railway trestle in structure, that cork pads and other vibration-damping provisions must be used to eliminate the slightest building tremors, although it has been installed directly on the foundations of the new Department of Commerce building.

Capt. R. S. PATTON, director of the U.S. Coast and Geodetic Survey, states that this gigantic instrument will make it possible to photograph a complete chart on one negative, with a probable error of not more than two-thousandths of an inch. Two years were devoted to its design, construction and adjustment, at a total cost of over $15,000.

In order to obtain the greatest accuracy possible, every available source of information was consulted from the designs of commercial copying cameras to reports of technical experts at the National Bureau of Standards. The preliminary designs were prepared at the Sight Shop of the Naval Gun Factory.

Shrink fits with "dry ice."—Solid carbon dioxide, popularly named "dry ice," may, at its temperature of −112 degrees Fahrenheit compete with heat in securing shrink fits for machine parts. W. H. SWANGER of the National Bureau of Standards, reports that machine shop practice may come to accept the new method of applying low temperature instead of heat in shrinking metals. When it is necessary to secure a metal band to a shaft, the usual practice is to heat the band. Expansion allows it to be slipped into place, and as it cools it contracts to a tight fit. However, by "refrigerating" the inside part, or shaft, it can be shrunk materially. The band is slipped on and when the shaft warms to room temperature it expands again to normal size, and a tighter fit is secured.

PERSONAL ITEMS

Dr. DAVID WHITE, eminent scientist of the U.S. Geological Survey, was awarded the Boverton Redwood medal by the Institution of Petroleum Technologists in London. This is the first time that the medal, highest award of the institution, has been given to an American and only the second time it has gone to a scientist outside the British Empire.